99B-145

UNIVERSITY OF CALIFORNIA, DAVIS

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14 April 1999

CALFED Bay-Delta Program Office
1416 Ninth Street, Suite 1155
Sacramento, CA 95814

Proposal Title: "Culture of Delta Smelt, Hypomesus Transpacificus, in Support of Environmental Studies and Restoration"
Principal Investigator – Serge Doroshov

Dear Colleague:

It is a pleasure to present for your consideration the referenced proposal.

It is our understanding that for purposes of determining applicant category, The Regents will be classified as "State" thereby resulting awards will only include the terms identified in Attachment D of the 1999 Proposal Solicitation Package as "Terms and Conditions for State (CALFED) Funds" and "Standard Clauses-Interagency Agreements".

The University takes exception to clauses pertaining to Substitution, Rights in Data and Indemnification as detailed in Attachment D. On behalf of The Regents of the University of California, we hereby reserve the right to negotiate said clauses as detailed in the Proposal Solicitation Package should this proposal result in a subsequent award.

Please call on the principal investigator for scientific information. Administrative questions may be direct to me or to Petrina Ho by telephone, facsimile or electronic mail at the numbers specified above. We request that correspondence pertaining to this proposal and a subsequent award be sent to the Office of Research and to the principal investigator.

Sincerely,

Sandra M. Dowdy
Contracts & Grants Analyst

Enclosures

I —0 1 5 1 4 0

PSP Cover Sheet (Attach to the front of each proposal)

Proposal Title: Culture of Delta Smelt, Hypomesus transpacificus, in Support of Environmental Studies and Restoration.

Applicant Name: Serge Doroshov

Mailing Address: Univ of California, Animal Science Dept, Meyer Hall, Davis, CA 95616

Telephone: 530- 752-7603 or 752-2058

Fax: 530- 752-0175

Email: sidoroshov@ucdavis.edu

Amount of funding requested: $ 431,606 for 2 years (10% state overhead)

Indicate the Topic for which you are applying (check only one box).

- ☐ Fish Passage/Fish Screens
- XXX ☒ Habitat Restoration
- ☐ Local Watershed Stewardship
- ☐ Water Quality
- ☐ Introduced Species
- ☐ Fish Management/Hatchery
- ☐ Environmental Education

Does the proposal address a specified Focused Action? XX yes _____ no

What county or counties is the project located in? USA

Indicate the geographic area of your proposal (check only one box):

- ☐ Sacramento River Mainstem
- ☐ Sacramento Trib: _____
- ☐ San Joaquin River Mainstem
- ☐ San Joaquin Trib: _____
- XXX ☒ Delta: All areas
- ☐ East Side Trib: _____
- ☐ Suisun Marsh and Bay
- ☐ North Bay/South Bay: _____
- ☐ Landscape (entire Bay-Delta watershed)
- ☐ Other: _____

Indicate the primary species which the proposal addresses (check all that apply):

- ☐ San Joaquin and East-side Delta tributaries fall-run chinook salmon
- ☐ Winter-run chinook salmon
- ☐ Late-fall run chinook salmon
- XXX ☒ Delta smelt
- ☐ Splittail
- ☐ Green sturgeon
- ☐ Migratory birds
- ☐ Other: _____
- ☐ Spring-run chinook salmon
- ☐ Fall-run chinook salmon
- ☐ Longfin smelt
- ☐ Steelhead trout
- ☐ Striped bass
- ☐ All chinook species
- ☐ All anadromous salmonids

Specify the ERP strategic objective and target (s) that the project addresses. Include page numbers from January 1999 version of ERP Volume I and II:

ERP Vol I (p 194-195) project addresses short & longterm objectives, ERP Vol II (p20-21) project addresses programmatic action for recovery, Strategic plan for ecosystem recovery (Table 5-1) and Stage 1 Action plan (Chap 6, p34; project addresses Goal 1, Goal 2, and Goal 6.

Indicate the type of applicant (check only one box):

☐	State agency	☐	Federal agency
☐	Public/Non-profit joint venture	☐	Non-profit
☐	Local government/district	☐	Private party
XXX ☒	University	☐	Other: _____

Indicate the type of project (check only one box):

☐	Planning	☐	Implementation
☐	Monitoring	☐	Education
XXX ☒	Research		

By signing below, the applicant declares the following:

1.) The truthfulness of all representations in their proposal;

2.) The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and

3.) The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

Serge Doroshov

Printed name of applicant

Signature of applicant

Sandra M. Dowdy

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I-015142

CULTURE OF DELTA SMELT, *Hypomesus transpacificus*, IN SUPPORT OF ENVIRONMENTAL STUDIES AND RESTORATION

Prof. Serge Doroshov (Principal Investigator)
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A PROPOSAL TO THE CALFED BAY–DELTA PROGRAM
February 1999 Proposal Solicitation Package

Financial Contact
Ann Day, Dept. of Animal Science, UC–Davis, Davis CA 95616, 530-752-4512(voice), 916-752-0175 (fax), jaday@ucdavis.edu.

Participants
California Department of Water Resources

April 1999

998-145

CULTURE OF DELTA SMELT, *Hypomesus transpacificus*, IN SUPPORT OF ENVIRONMENTAL STUDIES AND RESTORATION
< University of California, Davis >

I. Executive Summary

I. a. Project Description and Primary Biological and Ecological Objectives

The on-going Delta Smelt Culture Project is currently funded by CALFED, for the first year of a three-year program (funding ends June 30, 1999). The project is on track in developing a functional culture system for delta smelt; a threatened species endemic to the Sacramento - San Joaquin Estuary. This species is considered by CALFED to be a "high priority at risk species" (ERP Vol. I and II, 1999), and is included in the list of highest priority species dependent on the Delta (CALFED PSP, Goal 1).

All objectives outlined for the first year's delta smelt culture work (Phase 1, in progress) have been met or exceeded and we are on schedule for spring spawning and larval rearing trials. Renewed funding for our program will enable us to evaluate the important parameters of temperature and rearing-tank size on smelt performance, and to provide summary evaluation of system performance, culture protocols and methodologies.

The main objectives of the Delta Smelt Culture Project are to aid in species restoration by:

- Developing a reliable and technically feasible culture system for all life stages of delta smelt.
- Initiating the supply of live animals for testing in laboratory and field research.
- Providing data and observations on the development and behaviors of delta smelt.
- Creating a preserved developmental series of eggs through juvenile stages for comparisons to field fish, provides a standard for evaluating on-going habitat restoration in the delta.
- Creating a refuge population and, by procuring wild sub-adults for broodfish each fall, minimizing genetic changes. There are no plans to re-stock delta smelt.

A supply of cultured smelt is desired by a number of State and Federal Agencies:

This year we are supplying smelt for two UC-Davis projects: the fish treadmill project of Dr. Cech and associates, and the assessment of delta smelt health from various delta areas directed by Dr. Bennett and associates (funding from CALFED). This latter group plans to conduct contaminant exposure studies with this native species in 1999 and 2000.

In 1998 we supplied embryos to Dr. Huang (Dept. of Fish and Game) for toxicity testing of an herbicide (Komeen^{R}) used to control an exotic aquatic macrophyte, *Egaria densa*. Post-spawn adult smelt were supplied to Dr. Cech's group (UC-Davis) for testing in the fish treadmill.

In the near future a large supply of larval and juvenile smelt is desired by the US Bureau of Reclamation (US Bureau) and the California Department of Water Resources (DWR) for testing improvements in fish screen design and fish salvage operations, at the Central Valley Project (CVP) and the State Water Project (SWP). These agencies have funded this project in past years.

I. b. Budget Costs

Budgets have been prepared with both State (10%) and Federal (44.5%) funds overhead. Project total cost for funding Phase 2 and 3 with state funds is $431,606.00 ($559,446.00 Fed. cost). Broken down by year, cost to the State for the Phase 2: 1999-2000 is $212,253.00 ($275,059.00 Fed. cost), and $219,353.00 ($284,387.00 Fed cost) for Phase 3: 2000-2001. The major part of the budget supports three key personnel working full-time at the delta smelt culture facility. Their previous experience and technical skill are critically important in developing methods for culture and breeding of delta smelt.

I. c Adverse and Third Party Impacts

There are no foreseeable adverse or third party impacts by this small project located on State land.

I. d. Applicant Qualifications

Dr. Serge Doroshov has expertise in developmental biology and hatchery technology of cultured fish, including sturgeon, striped bass, catfish, trout, and marine species. Together with graduate students, he has developed a delta smelt prototype culture-system at UC-Davis and has characterized sexual maturation, gametogenesis, and early development in delta smelt. ***Dr. Joan Lindberg*** conducted her graduate studies on salmon metamorphosis and feeding behavior in sturgeon larvae. She led an independent pilot project on delta smelt spawning and culture at the SWP facilities in Byron before expanding the UC-Davis effort at that site. ***Dr. Bradd Baskerville-Bridges*** conducted his thesis research on the development of fish culture techniques for cod at the University of Maine before joining the smelt project. ***Joel Van Eenennaam*** has extensive experience in the breeding and culture of various fish species, including sturgeon and delta smelt; he will administer and track funds. ***Marade Walston*** has completed a BS Degree in Wildlife and Fisheries from UC-Davis and has gained experience in spawning, and rearing delta smelt.

I. e. Monitoring, Data Evaluation, and Scope of Work

This project is not directly related to monitoring and data evaluation programs. Some of the material of this project can be used for bio-monitoring program standards. For example, developmental charts for delta smelt (accounting for temperature effect) can be used in the analysis of captured larvae, and juveniles from various locations to examine dispersal, growth, and development in the wild population.

Scope of work includes the following tasks:

Phase 1: July 1998 - June 1999 (current CALFED contract B81581)

In the current phase of the project (previous funding cycle) we are completing the following tasks: (1) Site improvements; (2) Spawn technique development, initiation of rotifer culture and supply of eggs to researchers; (3) Larval culture development, and supply of larvae to researchers; (4) Post-larval fish collection; (5) Year-end report.

Phase 2: 1999 - 2000

Approval of the current proposal will enable work on the following tasks: (1) Site improvements and broodfish capture; (3) Broodfish, rotifer, and Artemia cultures; (3) Improve larval fish culture -test effect of temperature; (4) Capture of wild post-larvae; (5) Rear cultured juvenile fish; (6) Year-end report preparation and dissemination.

Phase 3: 2000 - 2001

The third year effort will include the following tasks: (1) Site improvements and broodfish capture; (3) Broodfish, rotifer, and Artemia cultures; (3) Improve larval fish culture -test increased scale production-system; (4) Capture of wild post-larvae; (5) Rear cultured juvenile fish in larger, production, system; (6)Prepare 3-year summary of smelt culture system: design, protocols, performance, and smelt biology. Prepare manuscript for publication.

I. f. Local Coordination with other Programs and Compatibility with CALFED objectives

Interest in the proposed study has been voiced from the Department of Water Resources, Federal Bureau of Reclamation, Department of Fish and Game, Interagency Ecological Program, and the University of California-Davis.

Restoration of delta smelt is listed by CALFED as a Priority Group I Objective under Goal 1: Endangered Species (Strategic Plan for Ecosystem Restoration, Draft 2/99). The document maintains that delta smelt, and many of the Priority Group I fishes, are recoverable through restoration of the Delta and Suisun Bay areas. Restoration involves both improvements in physical properties of the Delta, and improvements in information to allow better management of the ecosystem (Strategic Plan, p. 32). The current project is designed to contribute to the latter. That is, by supplying delta smelt life stages to other research projects, and by recording fundamental information on delta smelt biology, this project contributes to restoration and management efforts in the Delta ecosystem.

II. Project Description and Proposed Scope of Work

II. a. Project Description

Our proposed project will build upon successes in delta smelt culture achieved over the last several years at UC-Davis and the State Water Project (SWP) Fish Facility in Byron. Our team has successfully advanced methods for the capture, spawning, incubation, and rearing of smelt on a pilot scale (Lindberg 1992, 1996 1998a 1998b; Mager 1996, Mager et al. 1996). We propose to refine and apply these methods to the culture of delta smelt in the expanded hatchery facility at the Byron site. A secondary objective is the evaluation of light-trap capture of wild smelt in Clifton Court Forebay.

Producing a supply of cultured smelt will serve a variety of research interests. Smelt embryos reared in ozonated delta water provide toxicologists with a known initiation point from which to launch contaminant exposure studies. Fish culture is the only method of filling this need. Other studies, such as fish screen development and improvement efforts, could be supplied with either hatchery-reared or captured juveniles.

II. b. Proposed Scope of Work

Due to the complex nature of the culture system required to rear delta smelt a project of three years was initiated. Sub-adult fish are captured each fall and over wintered to create a stock of captive broodfish. The small size of the larval and post-larval smelt and the extended term of this life stage requires the culture of live prey cultures and intense labor to keep the larval vessels clean. In the past, progress has been hindered by interrupted funding; in order to provide a continuous supply of smelt at all life stages the project requires year round support. The scope of work is outlined as a series of tasks in each of three years, or Phases, corresponding to the current and funded year (Phase 1, 1998-1999) and two subsequent years (Phase 2 & 3). We dedicate the current and second years of the project to a series of small scale experiments directed primarily at improving larval to juvenile phase culture methods rather than in pursuit of larger scale production techniques. This strategy allows us to test factors influencing larval culture and then evaluate and adapt the best methods to a higher production culture in the third year.

Scope of work includes the current, funded, Phase 1 and the proposed Phases 2 & 3

Phase 1, July 1998 - June 1999, Current Year - supported by CALFED (contract B81581):
To date we are on track with the current year's objectives outlined in the CALFED Final Contract Agreement (Contract B81581) and as summarized in the January '99 Quarterly Report (Attachment A). Tasks are listed below with a description of progress in completing the tasks.

Task 1. Physical improvements; Jul 98 - Feb 99

- Purchased equipment to convert a shipping container into a hatchery; electrical, plumbing, and tanks installed for rearing egg and early life stages of delta smelt.
- Installed ozonation equipment to continuously disinfect delta water. The system includes three large settlement tanks, an ozonation tower, tanks for removal of residual ozone and water storage, and a water chiller for temperature control.
- Created a warm-water supply, at 10ppt salt concentration, to support live prey cultures.

Task 2 Broodfish capture and holding, and rotifer culture; Nov 98 - Jun 99

- Collection of 360 sub-adult delta smelt (with the assistance of the Dept. of Fish and Game) yielding 272 live broodfish as of 1/99; perform daily maintenance through June.
- Increase in prophylactic drug treatment frequency is reducing losses due to spawning stress.
- Culture of rotifers, *Brachionus plicatilus*, was initiated in March. Production has increased to the larval needs of 15 million rotifers/day. Maintenance: daily counts from each of 4 150-liter tanks, harvesting, and re-inoculation of new tanks, and 5 feedings/day.
- Collection of small spawns from the broodfish this year has begun and will continue until mid-June. Embryos that are fertile appear to be developing nicely in the ozonated water. Maintenance includes egg counts, daily removal of dead, and anti-fungal treatments.
- Initiate supply of eggs to other researchers.

Task 3. Optimization of the larval culture procedures; Mar - Jun 99

- Rearing of small test group of larvae (eggs stripped from fish at the Federal CVP) indicates larvae survive and feed in both the bio-filtered and ozone treated waters of our new hatchery.
- Testing for larval performance in two clean water supplies: re-circulating water (with bio-filtration), and ozonated water (flow-through system). Sub-sample larvae at 0, 10, 20, and 30 days post hatch; measure dry weight and length. Determine survivorship at end trial.
- Testing for larval performance reared in two tank sizes. Pool larvae from several spawns and stock into 20 or 120 liter tanks (2 replicates/treatment). Take data as above.
- Conducting short-term larval feeding trials to test effect of several factors on prey ingestion. Factors include: recirculating water, and ozone treated water, with and without algae suspension added, algal suspension added at several concentrations, water turbidity and filtrate of algal suspensions. Stock 30 larvae in 2-liter beakers, 3 beakers/treatment, acclimate overnight. Add test factor(s) and rotifers, after 5 hour exposure, examine in gut contents.
- Initiate a supply of larvae to other researchers

Task 4. Capture of post-larvae from the field; Jun 99

- Set light traps during period of peak post-larval smelt (20-30mm) abundance. Abundance is monitored at the SWP and CVP fish screening facilities. Set traps (8) in Clifton Court Forebay before dusk, fish 1 hour before retrieval.
- Treat captured fish with anti-bacterial drugs; sort fish retaining smelts, stock to rearing tanks.
- Evaluate success of trapping smelt to provide a supply of juvenile fish for research.

Task 5. Summary of data and preparation of report, Jul 99 - Sep 99

- Current funding ends June 30. A no-cost extension agreement (Jul-Sep) allows time to prepare the year-end report, due Sep 99. Even with continued funding from CALFED this his scenario will result in the loss of animals reared to this point, and the loss of skilled personnel due to the break in funding.
- "Interim Funding" from Department of Water Resources and U. S. Bureau of Reclamation has been applied for to cover the period (Jul-Sep).

Phase 2: 1999 - 2000

In the second year of our program (first year under the current PSP) our primary focus will be to test the effect of temperature on larval fish performance, begin documentation of spawning behavior, and supply embryos and larvae to other researchers.

Task 1. Site improvements and broodfish capture; Oct 99-Sep 00

- Purchase and install ozone generator and air supply for generator.
- Purchase and install commercial refrigeration unit to cool new hatchery lab. Upgrade AC units in old lab.

Task 2. Broodfish maintenance and spawning; Rotifer and Artemia cultures; Jan-Jun 00

- Perform sub-tasks as outlined below (details as in Phase 1, Task 2 above), and incorporate improvements from Phase 1.
  - Collection of 400 sub-adult delta smelt (with the assistance of the Dept. of Fish and Game)
  - Increase in prophylactic drug treatment frequency is reducing losses due to spawning stress.
  - Initiate culture of rotifers, *Brachionus plicatilus*, and increase to 15 million rotifers/day.
  - Collection of eggs from broodfish and daily maintenance of developing embryos this year.
- Supply eggs to other researchers
- Test methods for video documentation of spawning behavior

Task 3. Improve larval fish culture system; Jan-Sep 00

- Make adjustments to larval rearing procedures based on Phase 1 year.
- Test effect of temperature on rearing success. Rear larvae at three temperatures.
- Test effect of water type at best rearing temperature: recirculating water vs flow-through water disinfected by ozonation.
- Supply larvae to other researchers

Task 4. Capture of post-larvae from the field, and maintenance; Apr-Sep 00

- Evaluate success of trapping smelt in Phase 1 work. Make adjustments to protocol in Phase 1.

Task 5. Rear cultured post-larvae and juveniles; Apr-Sep 00

- Monitor growth and survival of post-larvae, wean juveniles to prepared feed.

Task 6. Prepare Year-end report; Sep 00

- Evaluate effect of rearing temperature on larval performance.
- Make recommendations for increasing scale of production for following year.

Task 7. Project Management; Oct-Sep 00

- Prepare budgets and track financial status of project.
- Review proposals and reports.

Phase 3: 2000-2001

In the third year of our program, we will test methods to increase production of larvae and juveniles based on previous years' results. We will begin video documentation of larval feeding behavior, and supply embryos, larvae and juveniles to other researchers. We will characterize the performance of smelt in the production culture system, and prepare manuscript of the summary methodology for delta smelt culture with recommendations for its application.

Task 1. Site improvements and broodfish capture; Oct 00-Sep 01

- Make adjustments to system, ie. replacement of older water chillers, installation of larger production tanks and plumbing systems.
- Capture sub-adults from field, and maintain over winter.

Task 2. Broodfish spawning; Rotifer and Artemia cultures; Jan-Jun 01

- Perform sub-tasks as in Task 2 from Phase 2 above. Incorporate improvements from Phase 2.
- Supply eggs to other researchers.
- Documentation of spawning behavior, in altered environments.

Task 3. Optimize larval and post-larval to juvenile rearing methods Jan-Sept 01

- Test effect of larger scale production tanks with best rearing temperature and water type- based on results of previous two years work.
- Test effect of stocking densities of 25, 50, and 75 larvae/ liter.
- Develop methods for video documentation of larval feeding behavior.

Task 4. Capture of post-larvae from the field, and maintenance; Apr-Sep 01

- Level of effort devoted to task depends on results of Phase 1 & 2 work.

Task 5. Rear cultured post-larvae and juveniles; Apr-Sep 01

- Monitor growth and survival of post-larvae in larger production scale system.

Task 6. Prepare 3-Year Summary of Culture Methodology; Sep 01

- Evaluate effect of rearing temperature and tank size on larval and juvenile performance.
- Summarize delta smelt culture system: design, protocols, performance, and smelt biology.

Task 7. Project Management; Oct-Sep 01

- Prepare budgets and track financial status of project.
- Review proposals and reports.

II. c. Location

The Smelt Culture Project is located in the south delta on State owned land at the SWP's Skinner Fish Facility near Byron, CA. The UC-Davis fish laboratories at the Institute of Ecology and Animal Science will be used for fish and tissue sample processing, and water quality analysis.

III. Ecological and Biological Benefits

III. a. Ecological and Biological Objectives

The decline in delta smelt abundance in the delta since the early 80's prompted listing the fish as *threatened* in the early 90's, and launched studies to determine the cause of the decline. Suggested causes for decline include loss of shallow water habitat, entrainment at Federal and State pumping plants, competition with introduced species, contaminant concentration in the delta, and changes in prey organisms and abundance (Moyle et al., 1992; USFWS, 1995). Current research has begun to address the importance of these factors. Substantial resources are going into the design and reclamation of farm land and seasonally flooded lands to restore spawning and nursery habitat for the delta smelt and other native species. Monitoring and assessment of these large scale projects is challenging and very important.

A primary goal of the Delta Smelt Culture Project is to assist these research efforts by producing fundamental details of smelt biology. ***To date, the project has contributed valuable information on developmental and behavioral biology of smelt including descriptions of gonadal maturation, spawning behavior, and timing of egg and larval development (Lindberg et al. 1998a and 1998b, Lindberg 1995, Lindberg 1992, Mager 1996, Mager et al. 1996).*** Additional contributions are anticipated from the culture project and from other projects using cultured smelt in areas such as spawning behavior, photo-taxis of larvae, prey capture and prey preference. For example, a single spawning observation has been reported to date (Lindberg 1992); future documentation of broodfish spawning in Phase 2 of our project will be useful to the ongoing habitat restoration projects.

An equally important objective is the creation of a supply of embryonic, larval, juvenile, and adult smelt in support of numerous CALFED and other research projects. The limited number of smelt in the wild and their threatened status precludes collecting large numbers of these animals. Furthermore the techniques for capture and holding of these fish have only been developed for the sub-adult to adult stages. ***A cultured supply of delta smelt is an important step towards restoration of the species by enabling important environmental, developmental, and behavioral research projects.*** Examples include: (1) Dr. Bennett's (UC-Davis) current CALFED project on the projected role of contaminants in the decline of delta smelt; (2) Drs. Cech andSwanson's (UC-Davis) research on testing approach velocities of smelt - to assist in improving fish screen design; (3) State and Federal pumping facility efforts to refine fish-screen design. Other supported projects are listed in Section III. b. below.

Creating a supply of delta smelt at all life stages for research will address specific Stage 1 targets of the CALFED ERP Plan (p. 195, Vol. 1):

- ***Target:*** *Reduce adverse effects of CVP and SWP diversions during the period when larvae, juveniles, and adults appear in the delta* -- cultured and wild smelt are currently used to determine approach velocities to louvers and to test swimming performance at water velocity.
- ***Target:*** *Increase the amount of shallow-water habitat in areas critical to spawning and rearing* -- cultured smelt can aid in providing growth and development data on larvae and juveniles from known water and prey density conditions providing standards for habitat restoration projects; and provide information on spawning habitat preferences.
- ***Target:*** *Construct and improve fish facilities for Delta diversions,..... CVP and SWP diversions, and improve handling and salvage practices at diversions* -- cultured and wild smelt are currently used to determine approach velocities to louvers and are needed to test new fish screen designs currently under development at the CVP.
- ***Target:*** *Implement restoration actions identified in the Recovery Plan for the Sacramento-San Joaquin Delta Fishes Recovery Plan* -- cultured smelt serve as a refuge against extinction, aid in research to reduce the impact of water diversions, provide fish for evaluating contaminant effects, and provide data and preserved specimens for evaluating smelt from habitat restoration areas.

Durability of smelt-culture benefits stem from the body of information on the developmental and behavioral biology of the smelt and from the continuous supply of fish, at all life stages, the culture facility will produce. Additionally, funds from CALFED and the IEP program have produced two hatchery laboratories (the brood fish lab and the new egg and larval lab) that are essentially mobile. Techniques developed for this species would be applicable to longfin smelt and American shad - at the present location or by relocation of the labs.

III. b. Linkages of the Smelt Project to Past and Future Projects

The Delta Smelt Culture Project currently receives CALFED funding (July 1998 - June 1999) for the first Phase of a three Phase project. The project has received support from the State Department of Water Resources (DWR) and the U. S. Department of Reclamation (US Bureau) , and the Interagency Ecological Program (IEP). These agencies have funded the culture effort at three locations UC-Davis, State Hatchery at Elk Grove (1992 only), and the SWP site at Byron. Recently (1998) the Delta Smelt Culture project has been consolidated to the current SWP site on DWR land. These State and Federal agencies continue to show interest in the project's ability to provide basic information on the biology of the smelt, and in the potential supply of live smelt at all ages. The US Bureau is currently donating labor hours to our efforts. They stand to benefit from information obtained regarding smelt rearing and holding techniques as they move towards testing new fish screen designs. DWR personnel also contribute labor and some additional funding for operation and maintenance issues that arise at the SWP site.

During the last two years we have begun supplying smelt at various life stages to researchers. Healthy post-spawn fish have been supplied to Dr. Hanson (Hanson and Associates) for testing sensitivity to an acoustical barrier. In 1997 we have preserved some embryo and larval fish samples for two projects: the comparative morphology study of delta smelt and wagasaki smelt at the larval and juvenile stages by Dr. Wang (consultant); and the larval otolith-aging work of Mr. Grimaldo (DWR) and Mr. Sweetnam (Dept. Fish and Game). In 1998 we supplied live embryos to Dr. Huang for toxicity testing of a locally used herbicide (CDFG 1998). In 1999 we will supply delta smelt to Drs. Bennett and Cech for their current work (section III. a. above). We will also supply preserved larvae and juveniles to the US Bureau at the Tracy CVP site for developing larval identification techniques (Dr. Wang and Mr. Baskerville-Bridges). In future years, the demand for cultured smelt may escalate significantly. The Federal Bureau of Reclamation (CVP) is planning to build a new water diversion channel and fish screen for its Tracy fish screen site. They anticipate using delta smelt as a sensitive native fish species for testing new screen designs.

Direct and indirect linkages exist between the Delta Smelt Culture Program and the species restoration, habitat restoration and aquatic toxicology goals addressed by the CALFED ERP:

- ***Stage 1 Targets from the CALFED ERP Plan Vol. I (p195)***, - as described above in section III. a.
- ***Programmatic action for recovery described in the ERP Plan Vol. II (p.20-21).*** Delta smelt have been assigned "R" status (for 'Recovery') by the Conservation Strategy Team designating the delta smelt a species for which CALFED should have a goal of recovering the species within the ecological management zone (p.19). Programmatic action: *Restoration will come indirectly from increasing spring inflow and outflow, ... Reducing the effects of water diversions and contaminants..... survival of young and adult delta smelt.* --Cultured smelt can serve as a reference standard against which smelt captured at various locations in the delta can be compared. Cultured fish can be used in experiments, to better evaluate wild larval smelt performance (ie. comparisons can be drawn between fields fish and larvae reared at several prey levels, or with various prey types). Additionally, a supply of cultured smelt facilitates programs designed to reduce effect of environmental stressors, ie. testing new fish screen designs, or for testing effects of contaminants.

- ***Goals and Objectives set out in the Strategic Plan for Ecosystem Restoration (Table 5-1) & the Stage 1 Action Plan or List (Chap 6, p 34):***
  - ***Goal 1: Endangered Species*** - Restoration of delta smelt to the Delta and Suisun Bay is in the Priority Group 1 Actions. --Cultured smelt serve as a refuge population against extinction. Information on spawning and larval feeding habits obtained from culture operations assists with management decisions. A supply of cultured fish to other researchers accelerates information flow.
  - ***Goal 2: Ecosystem Processes and Biotic Communities*** - *Establish and maintain hydraulic regime that favors native species....and Habitats.* Monitoring of North Delta habitat rehabilitation projects is underway (Prospect Island, Little Holland Tract, Liberty Island; Chap 6)). Monitoring use of these habitats by smelt for spawning and nursery habitat is slated. --Observing smelt spawning behaviors in the lab can provide information on the micro-habitat selection for spawning; this is unknown at present. Cultured larval smelt provide a standard, of known age and rearing conditions, that may help with field data interpretation. Smelt can be reared at various prey densities (and potentially with various prey species) providing more information on smelt performance in the field.
  - ***Goal 6: Aquatic Toxicology*** - *Develop better understanding of how contaminants affect Bay-Delta species.* --The threatened delta smelt may serve as an important native test species for pesticide, non-cumulative types of contaminants, and unidentified contaminants - if cultured fish are available. Contaminant exposure studies with hatchery reared embryo or larval delta smelt are planned for 1999 or 2000 (Dr. Bennett, UC-Davis).

III. c. System-Wide Ecosystem Benefits

The Delta Smelt Culture Program can benefit the delta smelt recovery in the extended Delta region, from Napa River to Cache Slough and south to Clifton Court Forebay in two ways, by providing information on the biology of the animal and by creating a supply of smelt for research. The information obtained from spawning, rearing, observing and recording data can benefit the other research and monitoring projects. For example: documentation of spawning behavior can inform projects interested in the physical properties of habitat construction designed to provide increased spawning habitat for the smelt (restoration projects: Little Holland Tract, Prospect Island, Franks Tract). The supply of live animals at all life stages can benefit researchers working in the areas of: (1) monitoring the health of delta smelt in the wild, (2) contaminant exposure studies, (3) development of taxonomic keys for larvae, (4) improving fish screen design for water diversions in the delta.

III. d. Compatibility with Non- Ecosystem Objectives

The Delta Smelt Culture Program is compatible with the non-ecosystem objective of The Water Quality Program Action (Revised Draft Water Quality Program Plan, 1/99). Both the supply of cultured smelt and the methodology for rearing smelt, once documented, could make the delta smelt an ideal test animal for aquatic toxicology. Toxicity testing cannot be conducted until both the supply of animals is available and methods have been worked out to insure survival of a fairly high percentage of control (un-exposed) animals. The culture program is developing a supply of all life stages and methodologies for rearing them.

IV. Technical Feasibility and Timing

An alternate approach, other than the culture of smelt, is being tested by the Delta Smelt Culture Program this year as a means of creating a large supply of captive fish. ***The alternative approach is to collect a large number of post-larval delta smelt with light-traps as they come through Clifton Court Forebay and the SWP or CVP water diversion sites in the late spring.*** This method presents some problems and benefits as compared to the fish culture method of producing delta smelt. ***Perceived benefits of trapping 20-30mm delta smelt to create a captive supply include:*** (1) shortened work season, from year-round to about 6 months; (2) reduced labor requirements; (3)

salvage of the post-larval smelt population that may otherwise be "lost" to the delta via the water diversions, then the "take" may be reduced or waived. ***Perceived detriments of trapping 20-30mm delta smelt to create a captive supply include:*** (1) Trapping methodology has not been tested for larval or post-larval fish in the Forebay; (2) sorting and handling of post-larval fish may result in infection or death, (3) supply of post-larval fish is unpredictable (in wet water-years, as in 1998, only a handful of fish came through the SWP and CVP facilities); (4) capture, or "take", of post-larvae is higher than "take" of sub-adult smelt that will result in numerous spawns and embryos (5) embryos and larvae would not be available for research with the post-larval smelt capture method.

Success of the culture project depends to a large extent on securing year-round funding to prevent loss of animals or personnel. The tasks listed below illustrate the overlapping schedule of tasks and the 12 month span of the work:

- collect sub-adult population of smelt in the fall of each year, Oct-Nov
- rear these sub-adults to maturation, with daily maintenance through the winter, Nov-Jun
- initiate rotifer culture, and increase production to 15 million/day, Feb-Mar
- collect eggs from broodfish tanks, continued maintenance broodfish and embryos, Mar-Jun
- Artemia nauplii culture, Mar-Jul
- rear larvae and conduct smaller scale experiments on feeding behavior, Mar-Jul
- test light-trapping of post-larval smelt in Clifton Court Forebay, June
- rear juveniles through metamorphosis to sub-adults, Aug-Nov
- conduct data analysis and summarize findings from year, Sep - Nov

And cycle repeats:

- collect sub-adult population of smelt in the fall of each year, October-November, ...

In the past the project has been hindered by lack of continuous funding. The project is seasonal with each phase dependent on the previous one. A break in funding brings all culture work to an abrupt halt, and experienced personnel are let go. With culture methods in the research and development phase highly trained personnel are necessary to constantly evaluate and adjust the protocols in order to move the project forward. Some of the gains made can be lost with discontinuities in staffing. As the culture program develops and rearing methods become standardized highly skilled labor is less critical and the culture system becomes more economical.

Collection permits will be obtained prior to delta smelt collection. We anticipate the of 400-500 sub-adult delta smelt before mid-October 1999 & 2000, and capture of 200-2000 post-larvae (20-30mm) from Clifton Court Forebay - June 2000 & 2001. No NEPA or CEQA permits are required.

V. Monitoring and Data Collection Methodology

V. a. Biological / Ecological Objectives

The main objectives of the Delta Smelt Culture Project are to aid in species restoration by:

- Developing a reliable and technically feasible culture system for all life stages of delta smelt
- Initiating the supply of live animals for testing in laboratory and field research
- Providing data and observations on the development and behaviors of delta smelt
- Creating a preserved developmental series of eggs through juvenile stages for comparisons to field fish, provides a standard for evaluating on-going habitat restoration in the delta
- Creating a refuge population and, by procuring wild sub-adults for broodfish each fall, minimizing genetic changes. There are no plans to re-stock delta smelt.

The culture method adopted stems from the experience of the researchers and from review of literature on smelt culture (Akielaszek 1985, Kashiwagi et al. 1988, and Moring, 1985) and other fishes with small pelagic larvae (Baskerville-Bridges 1999, Baskerville-Bridges and Kling 1999, Reitan et al. 1994, Rosenlund et al. 1993, and Baxter 1981). The current problems we wish to address this year and in the next two years (current proposal period 1999-2001) stem from the culture problems associated with the larval phase of delta smelt. Delta smelt have a 2-3 month larval phase before full metamorphosis. During this phase they are fragile and more susceptible to disease. The maintenance of this life stage is labor intensive requiring frequent feedings of live prey (Bracionus plicatilis, and Artemia nauplii) through an 11 hour day . Methods have been described for rearing small numbers of larval delta smelt through transformation but with limited and variable success (Mager 1996, Lindberg 1998a 1998b). Methods to improve the larval-culture methodology are described in the next section.

V. b. Test Parameters and Data Collection

In the current year (funding through June 1999) we will focus primarily on optimizing larval rearing methods in the following ways (see also Table V-1; p. 9):

1. ***Test for effect of water type on larval fish performance:*** re-circulating (bio-filtered) water vs flow-through, disinfected (ozone treated) delta water. Rear fish to 40 days in 20-liter tanks, sub-sample fish at 0, 10, 30, and 40 days post hatch; n=10 fish/sampled and 2 replicates/treatment. Fish are fed with increased frequency over previous year's work (5 vs 2 times/day) and tanks will receive constant water flows of 200 ml/minute to maintain high feeding rates while flushing out old prey and algae, otherwise methodology is similar to larval rearing in 1998 (Lindberg et al 1998b).
2. ***Test for effect of rearing tank size on larval fish performance:*** 20-liter vs 120-liter tanks with both water types (from 1 above) will be tested. Rear fish to 40 days, sub-sample fish at 0, 10 and 30 and 40 days post hatch; n=10 fish/sample. Feeding and frequency will be 6 times/day with same prey density in each tank type; water flow-rates are proportionate to tank volume.
3. ***Conduct a series of four short-term larval feeding tests to evaluate factors influencing ingestion of prey.*** Most larvae, at onset of exogenous feeding, will not feed on rotifers until an algal suspension is added to the tank (Mager et al 1996, Lindberg et al 1998b). Larvae do not feed on the algae, but it promotes ingestion of prey. The mechanism(s) for this "green water effect" is unknown (Kjell et al 1993, Nicholas et al 1989, Naas et al 1992). Factors we aim to test include: water type (recirculating and bio-filtered water vs ozone treated water), effect of turbidity (algae vs bentonite), effect of age or experience (test older, feeding, larvae), and test the filtrate of algae vs algal cell suspension. Larvae (30) will be acclimated to 2-liter beakers over night, addition of test factors is added the following morning followed by rotifers (10/ml). After 5-hour exposure animals are fixed in 10% formalin for gut content analysis.

Hypotheses tested in Phase 2 are given in Table V-II (p. 10).

V. b. Data Evaluation

Number of samples for larval rearing experiments: 10 fish/sample, per four sample times, with two replicates/treatment. The number of replicates (2 tanks) is small but replication of the treatment or replicate will be performed as necessary. Protocol is similar to 1998 trials (Lindberg et al. 1998b).

Number of samples for larval feeding experiments: all 30 larvae will be fixed in rapid succession with 10% formalin for gut content analysis (number of rotifers eaten). Three replicates will be used. Protocol was successful in 1998 trials (Lindberg et al. 1998b).

Results will be graphically displayed and analysis of variance will be used to determine significance of treatment effects. A record of the year's data, including the record of eggs spawned/day and tank temperature over the spring season, will be stored electronically for public access.

Each year quarterly reports will be submitted as scheduled and summarized in a year-end report. In the third year we will summarize and prepare a manuscript for publication with evaluation of methodologies for delta smelt culture and recommendations for its application.

Table V-1. Hypotheses Testing and Data Collection, Phase 1: July 1998- June 1999; Delta Smelt Culture Project, UC-Davis

*Note: Hypotheses listed below are limited to the larval life stage because CALFED funding ends June 30th. Continued funding will allow grow-out of the current stock of fish to the juvenile stage with documentation.

Specific Questions to be Evaluated/ Null Hypotheses	Methods and Data Collection, from present to June, 30 1999. (See above *Note).	Data Evaluation Approach	Comments/ Study Priority
H_{O1}: Water type will have no effect on rearing of larvae.	The research site, State Water Project at Byron, has only south delta water available for the culture studies. This water contains numerous bacterial and fungal disease agents. We have researched and implemented ozonation as method to disinfect the delta water. Fish are reared in two types of water: (1) re-circulating water which cycles effluent water through biofiltration, and (2) single-path delta water with ozone treatment	Rear larvae to 40 days in each water system. Sub-sample fish at 0, 10, 30 and 40 days post hatch for length and weight, and determine survival.	Previous pilot studies indicated that larvae are highly susceptible to bacterial and fungal insults carried in the delta water. Testing cleaner water types this year may greatly improve survival. Re-circulating water, or "mature" water has been known to benefit some larval species in culture.
H_{O2}: Tank size will have no effect on rearing of larvae.	Larval fish are reared in two sizes of tanks, 20 or 100 liters. Fish density will be the same in both.	Growth and survival will be monitored as above.	If larger tanks produce similar results to smaller tanks rearing in the larger tanks would be much more economical in terms of space and of labor costs.
Short-term Larval Fish Experiments:			
H_{O3}: Ingestion of rotifers by larval smelt will not differ between larvae held in ozonated water and larvae held in re-circulating water, with and without algae added.	Larval fish will be acclimated to 2-liter beakers over night. In this test larvae will be acclimated in either ozonated water or the mature, re-circulated, water. Addition of rotifers plus algae are added in the morning. After 7-8 hours exposure larvae are fixed in formalin.	Stomachs contents of larvae are examined for percent of larvae with rotifers, and stomach fullness.	These short-term experiments can give useful information regarding the factors affecting food intake in larvae. Addition of an algal suspension for larval feeding is necessary in numerous larval species but the mechanism by which algae facilitates feeding is unknown.
H_{O4}: Ingestion of rotifers by larval smelt will not differ with algae or bentonite added to the water.	Same technique, using larvae that are exposed to algae or bentonite (small clay) particles.	Same technique	
H_{O5}: The concentration of algae required to elicit feeding in >70% of the larvae will not differ in progressively older larvae.	Same technique, using larvae that are at the first feeding stage and 1, 2, and 3 weeks older.	Same technique	
H_{O6}: The filtrate of the algae suspension will elicit the same feeding response as the algal suspension.	Same technique using chemical filtrate of algal suspensions to compare with cellular algal suspensions.	Same technique	

Table V-2. Hypotheses Testing and Data Collection, Phase 2: 1999-2000; Delta Smelt Culture Project, UC-Davis

*Note: Hypotheses listed below may be revised, or added to, after review of spring 1999 results.

Specific Questions to be Evaluated/ Null Hypotheses	Methods and Data Collection, from present to June, 30 1999. (See above *Note).	Data Evaluation Approach	Comments/ Study Priority
$H_{O}1$: Water temperature will have no effect on larval fish performance.	Fish are reared at three water temperatures: Commercial mixing valves installed to maintain three target water temperatures: 17, 19, 21 C.	Rear larvae to 40 days at each water temperature. Sub-sample fish at 0, 10, 30 and 40 days post hatch for length and weight, -determine survival.	Temperatures for testing represent delta temperatures for smelt nursery habitats. Determining optimal rearing temperature can improve larval rearing performance.
$H_{O}2$: Water type at best rearing temperature will have no effect on rearing of larvae	Larval fish are reared in the two water types: recircultaing and ozonated at best temperature from above.	Growth and survival will be monitored as above.	Re-circulating water, or "mature" water has been known to benefit some larval species in culture.
Short-term Larval Fish Experiments:			
$H_{O}3$: Water temperature will have no effect on ingestion of rotifers by larval smelt.	Larval fish will be acclimated to 2-liter beakers over night at test temperatures of 17, 19, or 21 C.. Addition of rotifers plus algae are added in the morning. After 5 hour exposure larvae are fixed in formalin.	Stomachs contents of larvae are examined for percent of larvae with rotifers, and stomach fullness or rotifer counts.	These short-term experiments can give useful information regarding the factors affecting food intake in larvae. Addition of an algal suspension for larval feeding is necessary in numerous larval species but the mechanism by which algae facilitates feeding is unknown. Here we are testing effect of temperature on total prey intake and on speed of ingestion, as well as effect of larval stocking density on prey intake.
$H_{O}4$: Water temperature will have no effect on ingestion of rotifers by larval smelt at 10, 20 and 30 minutes total exposure to rotifers.	Same technique, using larvae that are acclimated to 17, 19, or 21 C.	Same technique	
$H_{O}5$: Larval stocking density will have no effect on ingestion of rotifers by larval smelt, at same rotifer density.	Same technique, using larvae that are stocked at 25, 50, or 75 per liter.	Same technique	

IV. Local Involvement

The Delta Smelt Culture Project is a small contained operation, located on state property (DWR) in the south Delta. This proposal does not involve land acquisitions or restoration of public or private lands. Therefore the project is not impinging on other land owners, and it is unlikely to have any adverse effects on the public or private sector.

Local support has been shown on site by DWR personnel, and by Federal Bureau of Reclamation personnel who's land borders the state's land to the south. Strong support for the project has come from the Interagency Ecological Program and UC-Davis.

Letters describing our project in Contra Costa County have been sent to the County Board of Supervisors and to the County Board of Planning (3/23/99; Attachments B-1, and B-2).

VII. Cost

VII. a. Budget

The total budgeted costs requested for the two year proposal period from CALFED is $431,606.00 with State funds and $559,446.00with Federal funds. The difference in cost is due to a higher overhead rate for Federal funding (44.5% vs. 10% State). The Yearly and Quarterly Budgets are given for Phase 2, 1999-2000 (Table VII-1, VII-2; pp. 13 & 14) and Phase 3, 2000-2001 (Table VII-3, VII-4; pp 15 & 16).

The major part of the budget supports Three key personnel working full-time at the culture facility. Their previous experience and technical skill are important in developing successful methodology. Hourly help is needed to cover the 7 day work week and the intensive labor requirements (12 hour days) during the spring and summer.

Major items in the Material and Acquisition category for Phase 2, 1999-2000, include: Ozone generator and air supply (6000), a commercial air-cooling unit for the new hatchery (2000), storage container (1500), video equipment (1300), and computer equipment (1200). ***Major Items for Phase 3, 2000-2001, include:*** a commercial air-cooling unit for the old hatchery (2000), replacement of oldest water chiller (6000), dissecting microscope (1400), and balance (1500), fax and printer (1100).

Supplies and Travel costs are expected to be similar for Phase 2 and Phase 3, categories include: rental and monthly fees for microscope, 2 pagers, and phone service (2500), feeds for broodfish, rotifers, and larvae (2200), algae supplies (2500), water quality test kits (2500), plumbing and building supplies, tools (5500), equipment parts and maintenance (2600), office supplies and copying (1200). Travel expenses include funds for field work (4700) and meetings (3400).

Schedule of Milestones

The following milestones are based on a start date of October 1 1999 for Phase 2 and 3.

Phase 2: 99-00

Install refrigeration unit to cool new hatchery lab. Completion: February 2000.

Larval-rearing trials with three temperatures. Completion: July 2000.

Test methods for documenting spawning behavior. Completion: Aug 2000.

Provide embryos and larvae to research laboratories. Completion: Aug 2000.

Rear larvae through metamorphosis to juveniles. Completion: September 2000.

Year end report. Completion: September 2000.

Phase 3: 00-01

Document spawning behavior. Completion: Aug 2001.

Provide embryos, larvae, and juveniles to research laboratories. Completion: October 2001.

Test larval and juvenile rearing procedures at higher production levels. Completion: October 2001.

Summary evaluation of culture system and preparation of manuscript for publication. Completion: December 2001.

Table VII-1a. Total Budget Phase 2, 1999-2000.
Delta Smelt Culture Proposal; Doroshov/Lindberg, UC-Davis.

Task	Direct Labor Hours	Salary & Benefits	Supplies & Expenses	Travel	Equipment	Indirect Costs State 10% & (Federal 44.5%)	Total Cost State & (Federal)
Task 1 (Oct 99-Sept 00)	2313	46,351	6,000	4,000	12,000	5,635 (25,076)	73,986 (93,427)
Task 2 (Jan 00-June 00)	1922	36,157	3,000	1,500	0	4,066 (18,092)	44,723 (58,749)
Task 3 (Jan 00-Sept 00)	2966	50,273	6,000	1,700	0	5,797 (25,798)	63,770 (83,771)
Task 4 (Apr 00-Sept 00)	340	5,936	2,000	300	0	824 (3,665)	9,060 (11,901)
Task 5 (Apr 00-Sept 00)	583	5,860	2,000	600	0	846 (3,765)	9,306 (12,225)
Task 6 (Sept 00)	0	0	0	0	0	0	0
Task 7 (Oct 99-Sept 00)	320	10,371	0	0	0	1,037 (4,615)	11,408 (14,986)
TOTAL	8,444	154,948	19,000	8,100	12,000	18,205 (81,011)	212,253 (275,059)

Task 1: Site Improvements and Broodfish Capture
Task 2: Broodfish Maintenance and Spawning; Rotifer and Artemia Culture
Task 3: Improve Larval Fish Culture
Task 4: Capture of Post-Larvae from Field
Task 5: Rear Cultured Post-Larvae and Juveniles
Task 6: Prepare Year-End Report
Task 7: Project Management

Table VII-1b. *Quarterly Budget Phase 2, 1999-2000.*
Delta Smelt Culture Proposal; Doroshov/Lindberg, UC-Davis.

Task	Quarterly Budget Oct-Dec 99	Quarterly Budget Jan-Mar 00	Quarterly Budget Apr-Jun 00	Quarterly Budget Jul-Sept 00	Total Budget with 10% State Overhead and (44.5% Federal Overhead)
Task 1	37,561	22,152	10,137	4,136	73,986
(Oct 99-Sept 00)	(49,340)	(27,218)	(11,436)	(5,433)	(93,427)
Task 2	0	20,734	23,989	0	44,723
(Jan 00-June 00)		(27,236)	(31,513)		(58,749)
Task 3	0	11,362	20,971	31,437	63,770
(Jan 00-Sept 00)		(14,925)	(27,549)	(41,297)	(83,771)
Task 4	0	0	4,471	4,589	9,060
(Apr 00-Sept 00)			(5,874)	(6,027)	(11,901)
Task 5	0	0	1,907	7,399	9,306
(Apr 00-Sept 00)			(2,505)	(9,720)	(12,225)
Task 6	0	0	0	0	0
(Sept 00)					
Task 7	2,852	2,852	2,852	2,852	11,408
(Oct 99-Sept 00)	(3,747)	(3,746)	(3,747)	(3,746)	(14,986)
TOTAL	40,413	57,100	64,327	50,413	212,253
	(53,087)	(73,125)	(82,624)	(66,223)	(275,059)

Task 1: Site Improvements and Broodfish Capture
Task 2: Broodfish Maintenance and Spawning; Rotifer and Artemia Culture
Task 3: Improve Larval Fish Culture
Task 4: Capture of Post-Larvae from Field
Task 5: Rear Cultured Post-Larvae and Juveniles
Task 6: Prepare Year-End Report
Task 7: Project Management

Table VII-1a. Total Budget Phase 3, 2000-2001.
Delta Smelt Culture Proposal; Doroshov/Lindberg, UC-Davis.

Task	Direct Labor Hours	Salary & Benefits	Supplies & Expenses	Travel	Equipment	Indirect Costs State 10% & (Federal 44.5%)	Total Cost State & (Federal)
Task 1 (Oct 00-Sept 01)	2313	47,741	6,000	4,000	12,000	5,774 (25,695)	75,515 (95,436)
Task 2 (Jan 01-June 01)	1922	39,099	3,000	1,500	0	4,360 (19,402)	47,959 (63,001)
Task 3 (Jan 01-Sept 01)	2966	51,781	6,000	1,700	0	5,948 (26,469)	65,430 (85,950)
Task 4 (Apr 01-Sept 01)	340	6,114	2,000	300	0	841 (3,744)	9,255 (12,158)
Task 5 (Apr 01-Sept 01)	583	5,984	2,000	600	0	858 (3,820)	9,442 (12,404)
Task 6 (Sept 01)	0	0	0	0	0	0	0
Task 7 (Oct 00-Sept 01)	320	10,684	0	0	0	1,068 (4,754)	11,752 (15,438)
TOTAL	8,444	161,403	19,000	8,100	12,000	18,850 (83,884)	219,353 (284,387)

Task 1: Site Improvements and Broodfish Capture
Task 2: Broodfish Maintenance and Spawning; Rotifer and Artemia Culture
Task 3: Improve Larval Fish Culture
Task 4: Capture of Post-Larvae from Field
Task 5: Rear Cultured Post-Larvae and Juveniles
Task 6: Prepare 3-Year Summary of Culture Results and Methodologies
Task 7: Project Management

Table VII-1b. Quarterly Budget Phase 3, 2000-2001.
Delta Smelt Culture Proposal; Doroshov/Lindberg, UC-Davis.

Task	Quarterly Budget Oct-Dec 00	Quarterly Budget Jan-Mar 01	Quarterly Budget Apr-Jun 01	Quarterly Budget Jul-Sept 01	Total Budget with 10% State Overhead and (44.5% Federal Overhead)
Task 1	38,605	22,555	10,177	4,178	75,515
(Oct 00-Sept 01)	(50,712)	(27,747)	(11,488)	(5,489)	(95,436)
Task 2	0	21,281	26,678	0	47,959
(Jan 01-June 01)		(27,955)	(35,046)		(63,001)
Task 3	0	11,617	21,406	32,407	65,430
(Jan 01-Sept 01)		(15,261)	(28,118)	(42,571)	(85,950)
Task 4	0	0	4,567	4,688	9,255
(Apr 01-Sept 01)			(6,000)	(6,158)	(12,158)
Task 5	0	0	1,940	7,502	9,442
(Apr 01-Sept 01)			(2,549)	(9,855)	(12,404)
Task 6	0	0	0	0	0
(Sept 01)					
Task 7	2,938	2,938	2,938	2,938	11,752
(Oct 00-Sept 01)	(3,860)	(3,859)	(3,860)	(3,859)	(15,438)
TOTAL	41,543	58,391	67,706	51,713	219,353
	(54,572)	(74,822)	(87,061)	(67,932)	(284,387)

Task 1: Site Improvements and Broodfish Capture
Task 2: Broodfish Maintenance and Spawning; Rotifer and Artemia Culture
Task 3: Improve Larval Fish Culture
Task 4: Capture of Post-Larvae from Field
Task 5: Rear Cultured Post-Larvae and Juveniles
Task 6: Prepare 3-Year Summary of Culture Results and Methodologies
Task 7: Project Management

IX. Applicant Qualifications

Dr. Serge Doroshov, Principal Investigator

Education

Ph.D.: Biology/Oceanography, Academy of Science, Moscow, Russia, 1967.
M.S. and B.S.: Zoology/Ichthyology, University of Moscow, Russia, 1959.

Employment History

1995-present: Director of the Aquaculture and Fisheries Program, University of California–Davis.
1978-present: Associate Professor and Professor of Animal Science, University of California–Davis.
1967-1975: Head of the Laboratory of Mariculture, VNIRO, Moscow, Russia.

Research Experience

Developmental biology and reproductive physiology of fish (striped bass, sturgeon, delta smelt, catfish, trout). Fish culture and hatchery technology.

Dr. Joan C. Lindberg, Project Manager

Education

Ph.D.: Ecology, University of California–Davis, 1988. Dissertation: Feeding and behavior studies in larval and juvenile white sturgeon, *Acipenser transmontanus*.
M.S.: Zoology, University of Wisconsin–Madison, 1983.
B.S.: Zoology, University of Wisconsin–Madison, 1979.

Employment History

1996-Present: Postgraduate researcher, University of California–Davis.
1994-1996: Research associate, San Francisco State University, San Francisco, CA.
1990: Instructor of General Biology, Las Positas College, Livermore, CA.
1988-1990: Postdoctoral study, Lawrence Livermore National Lab, Livermore, CA.

Research Experience

Project development, management and construction of delta smelt culture program. Directed pilot study to assess use of restored wetland habitat for spawning by delta smelt. Research on juvenile sturgeon feeding behavior in culture system. Research on salmon imprinting physiology. Assessment of molecular toxicology technique to detect DNA damage in striped bass.

Joel Van Eenennaam, Project Administrator

Education

MS: International Agriculture Development (Aquaculture Specialization), University of California–Davis, 1985.
BS: Fisheries and Wildlife, Michigan State University, 1977.

Employment History

1985-present: Research Associate, UC Davis.
1983-1985: Research Assistant, UC–Davis
1982: Aquaculture Technician, Fish Breeders of California.
1977-1981: Fisheries Extension Agent, Khon Kaen, Thailand.

Research Experience

Reproductive and developmental biology of cultured fish (sturgeon, paddlefish, striped bass, catfish, trout, common, chinese and Indian carps, tilapia, bluegill). Development of hatchery technology in aquaculture. Organization of workshops in broodstock development, spawning induction, egg and larval rearing. Supervision of the sturgeon broodstock development program in California and the western region. Research on the reproductive conditions of Atlantic sturgeon on the Hudson River, NY. Supervision of several wet and dry laboratories at UC–Davis for research on reproductive biology of fish.

IX. Applicant Qualifications, cont.

Dr. Bradd Baskerville-Bridges, Post Graduate Researcher

Education
Ph.D.: Marine Bio-Resources, University of Maine- Orono, 1999. Dissertation: Studies on rearing and early weaning of Atlantic cod (Gadus morhua) larvae onto commercial and experimental microparticulate diets.
B.A.: Aquatic Biology, University of California- Santa Barbara, 1992

Employment History
11/98 to present: Post Graduate Researcher, University of California- Davis.
9/93 to 10/98: Research Assistant, University of Maine- Orono.

Research Experience
Investigated rearing techniques of cod larvae during early life stages. Developed and evaluated experimental microparticulate diets for use in early weaning trials. Extensive experience with live feed production systems (algae, rotifer, and Artemia).

Marade Walston, Laboratory Assistant
Education
B.S.: Wildlife and Fisheries, University of California–Davis, 1997

Employment History
1/99 -present: Laboratory assistant, University of California–Davis.
3/98-12/98: Scientific aid, California Department of Fish and Game, Stockton, CA.

Research Experience
Larval fish identification. Maintenance of delta smelt broodfish and rotifer cultures, and rearing of embryos, larvae. Daily assessment of water quality parameters in larval delta smelt tanks.

References

Akielaszek, J. J., J. R. Moring, S. R. Chapman, and J. H. Dearborn. 1985. Experimental culture of young rainbow smelt, *Osmerus mordax*. Trans. Amer. Fish. Soc. 114: 596-603.

Baskerville-Bridges, B. 1999. Studies on rearing and early weaning of Atlantic cod (Gadus morhua) larvae onto commercial and experimental microparticulate diets. Ph.D. Dissertation. University of Maine, Orono, Maine, 162 pp.

Baskerville-Bridges, B. and L. J. Kling 1999. Culture of Atlantic cod (Gadus morhua) at high larval stocking densities. Aquaculture - in press.

Blaxter, J.H.S. 1981. The rearing of larval fish. Aquarium Systems. Hawkins, A.D. London, Academic Press: 304-323.

Kashiwagi, M., T. Iwai, and A. N. G. Lopes. 1988. Effects of temperature and salinity on egg hatch of the pond smelt, *Hypomesus transpacificus*. Bull. Fac. Bioresources, Mie University 1: 7-13.

Kjell, I. R., J. R. Rainuzzo, G. Oie and Y. Olsen. 1993. Nutritional effects of algal addition in first feeding of turbot (*Scopthalmus maximus* L.) larvae. Aquaculture 118: 257-272.

Lindberg, J. C. 1992. Development of delta smelt culture techniques. Progress report, California Department of Water Resources.

Lindberg, J. C. 1996. Delta smelt culture, State Water Site, 1995. Final report, California Department of Water Resources, Contract B-59776, 24 pp.

Lindberg et al. 1998a Delta smelt culture; year-end report 1998. Progress report, California Department of Water Resources, Sacramento; October 1998; Contract B-81355, 20 pp.

Lindberg et al. 1998b. Delta smelt culture,1997. Progress report, California Department of Water Resources, Sacramento; March 1998; Contract B-80999, 24 pp.

Mager, R. C. 1996. Gametogenesis, reproduction, and artificial propagation of delta smelt, Hypomesus transpacificus. Ph.D. Dissertation, University of California–Davis, 125 pp.

Mager, R. C., S. I. Doroshov, and J. P. Van Eenennaam. 1996. Development of laboratory culture of delta smelt. Final report, Department of Water Resources, Fund title DWR B-59306, 65 pp.

Moring, J. C. 1985. Smelt culture. Maine Fish and Wildlife Summer, pp 13-15.

Moyle, P. B., D. E. Stevens, and L. W. Miller. 1992. Life history and status of delta smelt in the Sacramento–San Joaquin Estuary, California. Trans. Amer. Fish. Soc. 121 (1): 67-77.

Naas. K. E., T Naess and T. Harboe. 1992. Enhanced first feeding of halibut larvae (*Hippoglossus hippoglossus* L.) in green water. Aquaculture 195: 143-156.

Nicholas, J. L., E. Robic and D. Ansquer. 1989. Bacterial flora associated with a trophic chain consisting of microalgae, rotifers and turbot larvae: influence of bacteria on larval survival. Aquaculture, 83: 237-248.

Reitan, K. I., J. R. Rainuzzo, G. Oie and Y. Olsen. 1994. Nutritional effects of algal addition in first feeding of turbot (Scophthalmus maximus L.) larvae. Aquaculture, 118, 257-275.

Rosenlund, G., Meslo, I., Rodsjo, R. and H. Torp. 1993. Large scale production of cod. Proceedings of the first International Conference on Fish Farming Technology, Trondheim, Norway, A.A. Balkema.

U.S. Fish and Wildlife Service. 1995. Sacramento–San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

Attachments to Text (3)

Attachment A	CALFED Quarterly Report, Jan 99
Attachment B-1	Letter to Contra Costa County Board of Supervisors
Attachment B-2	Letter to Contra Costa County Board of Planners

Attachment A. p1.

Animal Science Department, UC -Davis, Davis CA, 95616

Quarterly Report

From: Drs. Joan Lindberg and Serge Doroshov
925-443-2448; lindberg@jps.net

To: CALFED Bay-Delta Program

Project: B81581, Delta Smelt Culture, State Water Project site - Byron
Date: 1/7/99

The objective of this project is to develop methods to culture the threatened fish, delta smelt. Numerous researchers are looking for a supply of smelt for basic and applied research, such as toxicology testing and improved fish screen design work. We are funded by CALFED for the first year of a three year grant. Emphasis in the first year is on improving the physical facilities at our site, optimizing spawn performance and larval culture procedures. Developing methods for the capture of post-larvae from the field for culture will be a minor emphasis this year.

This progress report briefly summarizes the progress from July 98 to present, 6 months. Previous culture work at this site has been funded by the Inter-agency Ecological Program.

I. Physical improvements at the site, and development of method to sterilize the delta water are our first priorities; July - December '98

We are nearing completion of the new laboratory (shipping container box) brought on site 3/98.

- Electrical wiring is completed - providing lighting and capacity to install the new water chilling unit recently purchased.
- The lab is plumbed with PVC pipe to provide water and drain lines to all tanks
- The container is partitioned to accommodate culture of the following life stages of delta smelt: eggs, larvae, and post-larvae to juvenile stages. Room has also been allocated for rotifer and brine shrimp cultures.

Creation of a sterile water supply was thought necessary after further review of last season's results with initial larval rearing trials. These preliminary rearing trials indicated that larvae reared with a supply of commercial drinking water did not exhibit the disease problems of the larvae reared with delta water. No clean water, such as well water, is available at the site. It is cost prohibitive to haul in water for larger scale rearing trials. We investigated two methods for disnfecting the delta water: batch chlorination and subsequent de-chlorination, or continuous ozonation of the delta water. We met with Professor Raul Piedrahita, aquaculture engineer UC-Davis, he advised us to adopt ozonation, and suggested we visit Bodega Marine Lab to see it in practice. After our visit and further reading we decided to adopt the ozone technology for our site. We are currently running some tests of the procedure. We are analyzing the delta water before and after ozonation to determine if it is effective in eliminating dissolved organics and bacteria. We will then determine the size of the ozone generator needed for our project.

Rearing trials with larvae will include use of both a clean water supply that is a flow through water supply and a "mature" re-circulating water supply. A mature supply of water is an advantage with some larval species. Extensive disinfection of the water also offers a higher success rate with many species.

Attachment A. p 2

II. *Collection and maintenance of broodfish, testing of larval systems, and initiation* of rotifer culture are our next priorities; November '98 - February '99

Collection of broodstock was accomplished quickly in late October. With the assistance of California Department of Fish and Game's boat and personnel we netted 360 fish in four trips. Survival to date is 75%. We now have 272 adult broodfish and we are on target for the spring spawning season.

Maintenance of broodfish is a daily routine since capture. Tanks are siphoned and wiped down and fish fed. Dead fish are removed and weights and lengths recorded. Fish are treated as necessary with nitrofurazone and formalin to prevent spread of disease.

Inoculation of the re-circulating water supply for larval rearing trials was done in mid-December to allow time for the bacteria to become established for the mature water supply. We will use two sizes of larval tanks to test for effect of tank size on rearing outcome and we will test the effect of two water supplies. We are currently assembling all the tanks and will run preliminary tests with algae only to determine clearance times prior to the spawning season. The egg incubators have been repaired from last year and the troughs and stand to hold them are in place in the new lab. We are developing a volumetric method for estimating egg number vs. counting each egg. This will greatly reduce egg handling time over last year's method.

Rotifer culture will be purchased by the third week of February to allow two months to establish a large stable culture prior to feed-out . Target culture production is 15 million rotifers/day. We are investigating new diet supplements for rotifers and brine shrimp that can enhance larval fish performance; and have met with the suppliers of a cryo-preserved micro-algae and with a fish culturist at the Monterey Bay Aquarium.

Attachment A, p3

Delta Smelt Culture Project
QUARTERLY REPORT*

		Quarterly Budget				Annual Budget			
Applicant:	Doroshov/Lindberg								
CALFED Project No:	B-81581								
Budget year:	FY 98-99								
Statement Quarter:	July 98-Dec98 *Note: 6 month period	Budget	Accrued Expenditures	Variance	**	Budget	Accrued Expenditures	Balance to Complete	**
Task 1: (Phase 1)	Physical improvements at site	59,243	60,000	757		65,826	60,000	5,826	
Schedule:	July - Dec 98								
Percent Work Complete Task 1:	90%								
Task 2:	Broodfish collection and maintenance, rotifer culture	24,804	22,186	2,618		99,214	22,186	76,398	
Schedule:	Nov - June 99								
Percent Work Complete Task 2:	20%								
Task 3:	Larval rearing	0	0	0		23,427	0	23,427	
Schedule:	April - June 99								
Percent Work Complete Task3:	0%								
Task 4:	Post-larval field collection	0	0	0		6,403	0	6,403	
Schedule:	Jun-99								
Percent Work Complete Task 4:	0%								
Task 5:	Submit final report	0	0	0		0	0	0	
Schedule:	Oct-99								
Percent Work Complete Task 5:	0%								

* Note: this quarterly report covers a six month period, due to late receipt of contract monies in first quarter.

**Explanation of Budget Varianc No significant budget variances
Explanation of Budget Variance will include a narrative description of reasons for each referenced variance from above table.
Explanations are required only for significant variances.

Total Project Costs Breakdown:
Funding from CALFED: 194,870
Funding from others: N/A

Project Schedule:
Phase 1 one year
Phase 2 N/A

Attachment B-1

UNIVERSITY OF CALIFORNIA, DAVIS

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DEPARTMENT OF ANIMAL SCIENCE
TELEPHONE: (530) 752-1250
FAX: (530) 752-0175

ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616-8521

Delta Smelt Project
1184 Hillcrest Court
Livermore, CA 94550
(925) 443-2448
email: lindberg@jps.net

3/23/99

County Supervisor
Contra Costa County Board of Supervisors
651 Pine Street, Rm 108A
Martinez, CA 94553

Supervisor Gayle Uilkema:

Please allow me to inform you of a our research project underway within Contra Costa County. In soliciting renewed funding from the CALFED Bay Delta Program all applicants have been advised to inform the county of new or continuing projects within the county.

Since 1995 a small scale fish culture program has been underway to develop methods for rearing the threatened fish species, the delta smelt, *Hypomesus transpacificus*. This small native fish is endemic only to the Sacramento - San Joaquin Estuary. The causes behind the population decline in the early 80s and the continued low abundance of smelt is not known. Many factors are believed to play a role. A supply of delta smelt at all life stages would advance research into factors affecting the smelt population.

Feel free to stop by our facility located at the Skinner Fish Facility of the State Water Project at Byron, on Byron Hwy.

Thank you for your time and please indicate receipt of this letter.

Sincerely,

Joan Lindberg, Ph.D.
Project Manager

Sent 3/24

Attachment B-2

UNIVERSITY OF CALIFORNIA, DAVIS

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

DEPARTMENT OF ANIMAL SCIENCE
(916) 752-1250
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DAVIS, CALIFORNIA 95616-8521

Delta Smelt Project
1184 Hillcrest Court
Livermore, CA 94550
(925) 443-2448
email: lindberg@jps.net

3/23/99

Director
Contra Costa County Board of Planning
651 Pine Street, North Wing - 2nd Floor
Martinez, CA 94553

Director Dennis Barry:

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Sincerely,

Joan Lindberg

Joan Lindberg, Ph.D.
Project Manager

sent 3/24

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